W data at the LHC and flavor symmetry of the sea at low x

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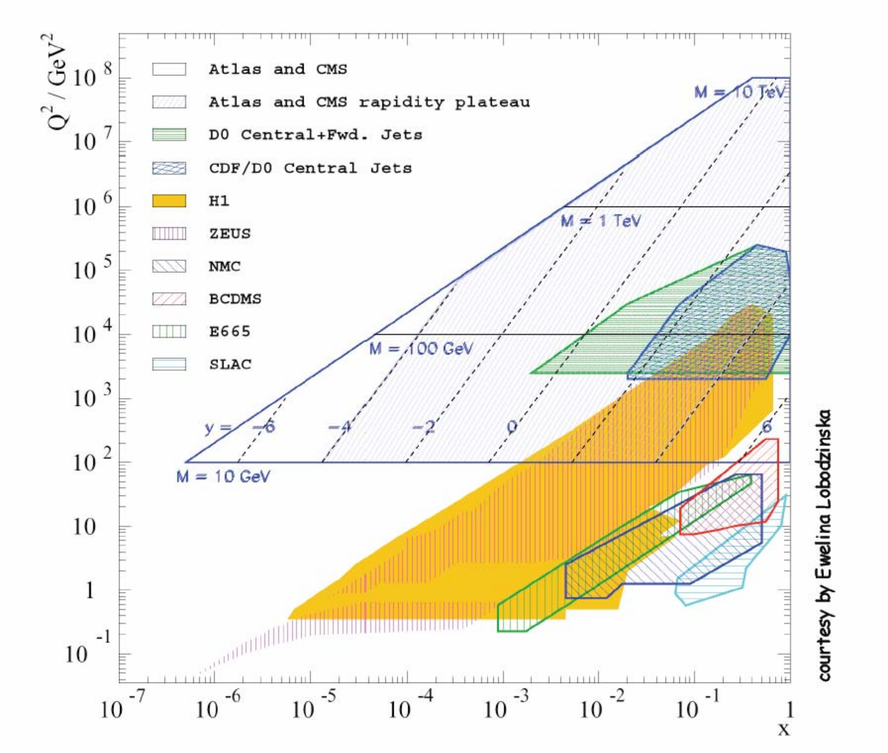


W at LHC : <x> ~ 7.10^{-3} at central eta
i.e. not in the valence region

Follow-up of a study by Max K. and Burkard R. in the HERA-LHC proceedings:

- usual assumptions on low x q and qbar
- impact of relaxing these assumptions on W predictions at LHC

A very first shot…

Starting point : H1PDF2k (like) fit

MK/BR,
March 2005

$$\begin{aligned} xg(x) &= A_g x^{B_g}(1-x)^{C_g} \cdot [1+D_g x] \\ xU(x) &= A_U x^{B_U}(1-x)^{C_U} \cdot [1+D_U x+F_U x^3] \\ xD(x) &= A_D x^{B_D}(1-x)^{C_D} \cdot [1+D_D x] \\ x\overline{U}(x) &= A_{\overline{U}} x^{B_{\overline{U}}}(1-x)^{C_{\overline{U}}} \\ x\overline{D}(x) &= A_{\overline{D}} x^{B_{\overline{D}}}(1-x)^{C_{\overline{D}}}, \end{aligned}$$

below bottom threshold

$$\begin{aligned} xU &= x(u+c) \\ x\overline{U} &= x(\overline{u}+\overline{c}) \\ xD &= x(d+s) \\ x\overline{D} &= x(\overline{d}+\overline{s}) \end{aligned}$$

At low x have only one measurement: $F_2 = \frac{4}{9} x\,(U+\overline{U}) + \frac{1}{9} x\,(D+\overline{D})$

assume that quark and anti-quark distributions are equal at low x, and u=d

$$B_U = B_D = B_{\overline{U}} = B_{\overline{D}} \equiv B_q$$

$A_{\overline{U}} = A_{\overline{D}} \cdot (1-f_s)/(1-f_c)$, which imposes that $\overline{d}/\overline{u} \to 1$ as $x \to 0$.

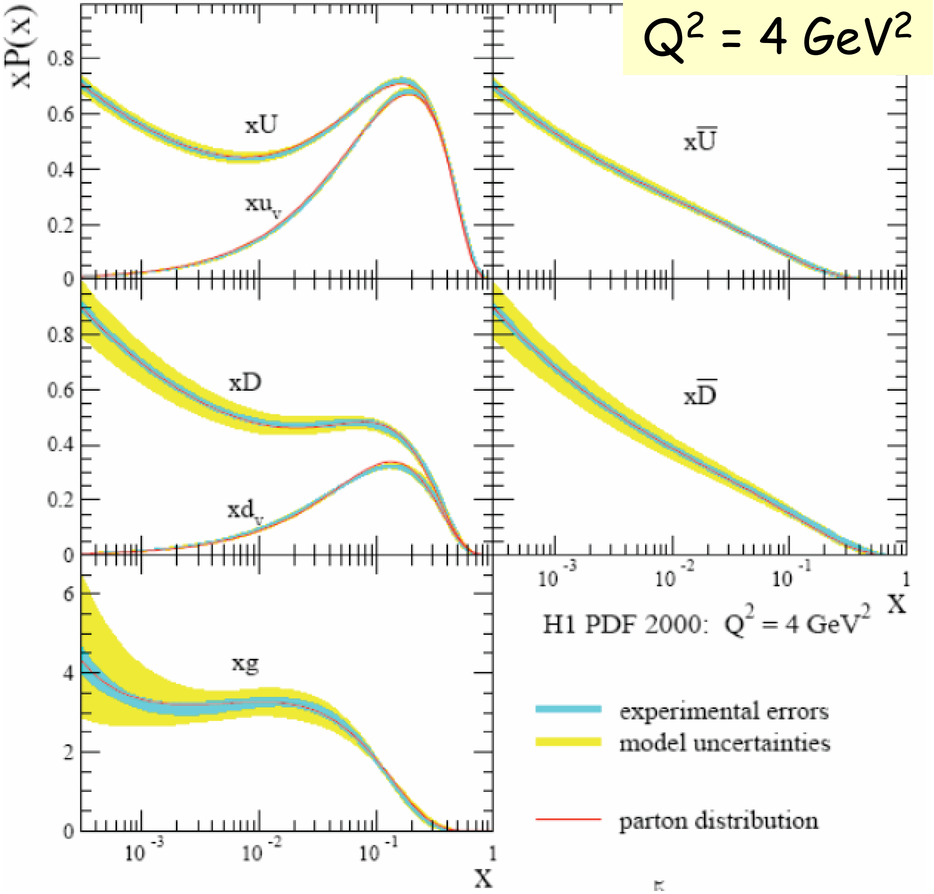
Following fits include : HERA I data (a la H1PDF2k)
BCDMS p and d data

MK/BR,
March 2005

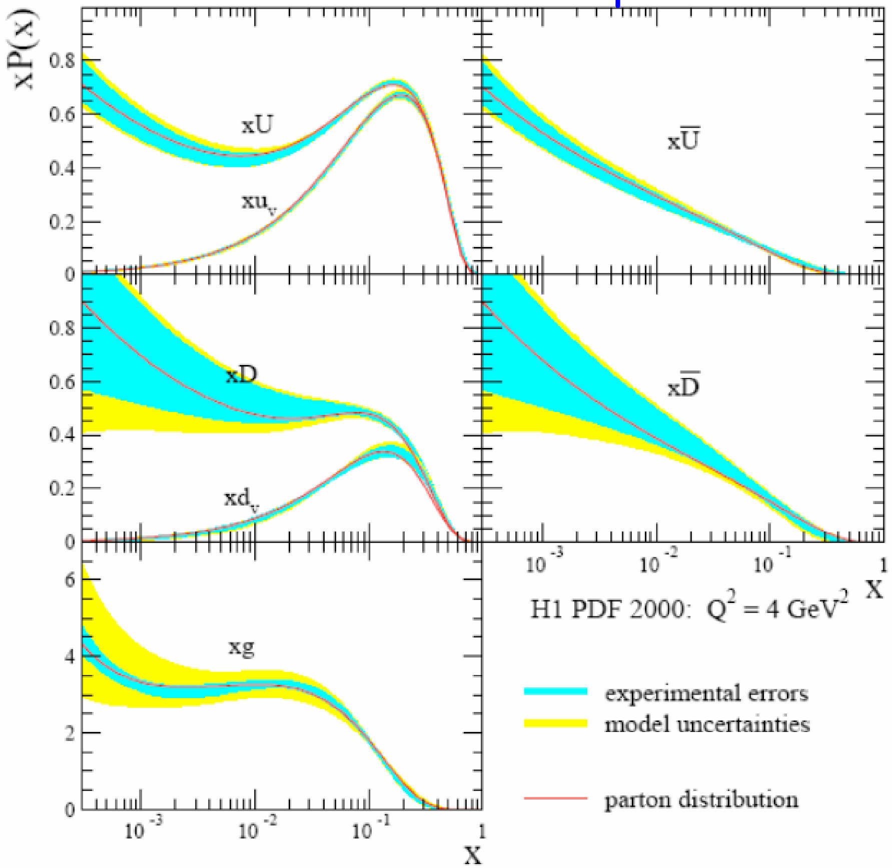
w / wo low x assumptions

With assumptions

$Q^2 = 4\ GeV^2$



Without assumptions



Relax $B_U = B_D$
& relation between A_U and A_D

i.e. still assume u=ubar, d=dbar,
relax ubar = dbar

eD at HERA would have helped a lot…

"Relaxed" PDFs and W at LHC

- Try to quantify the effect of relaxing the low x assumptions on W x-sections at the LHC
- Use MCFM (K. Ellis, J. Campbell) to calculate the cross-sections at NLO. Focus on $d\sigma / d\eta$(lepton)
- To run MCFM with the "relaxed" fit : put the relaxed PDF sets into a grid a la LHApdf.

PDF uncertainty : Hessian method, 25 sets for the relaxed fit.
Error obtained as

$$\sigma = \frac{1}{2} \left(\Sigma \left[a(S_i^+) - a(S_i^-) \right]^2 \right)^{1/2}$$

(the "error option" of MCFM gives the max. difference w.r.t. the central fit)

cf J. Pumplin et al, PRD 65 (2001) 014013

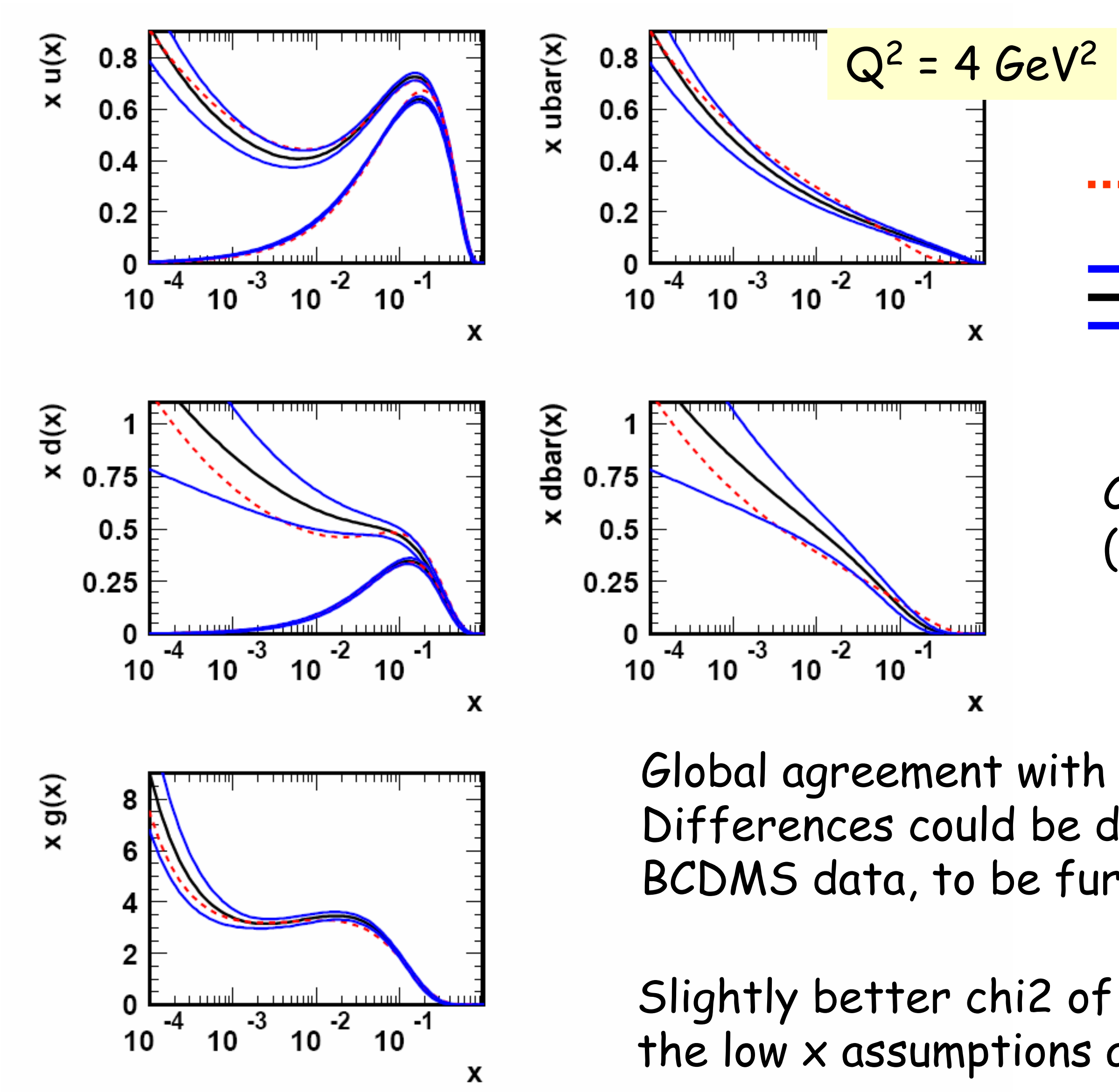
Fit program

"Common Fit Platform" developed within H1 (EP, T. Kluge, H. Jung, S. Glazov)
for all our H1 fit studies (inclusive, final states, diff., kt-fact.)

- Fortran code
- User can choose between collinear factorisation (QCDNUM based) or kT-factorisation (CASCADE based).
- Heavy Flavor : massless or massive
  ACOT and R.Thorne's scheme : work under progress
- Use standard MINUIT for the χ^2 minimisation
- Choice between different χ^2 definitions

- Correlated system. errors : systematic shifts determined analytically by the χ^2 minimisation (a la CTEQ) :
  $d\chi^2 / ds_k = 0$ gives a matrix equation for the (s_k)
- Error propagation : use the Hessian method. Use the MINUIT code of J. Pumplin ("ITERATE") to calculate iteratively the Hessian matrix.
  $\rightarrow$ if n parameters, get (2n+1) sets of PDFs.
- Interface to FastNLO for fits to final state data (DGLAP case).

Cross-check of the "relaxed" fit



H1pdf2k

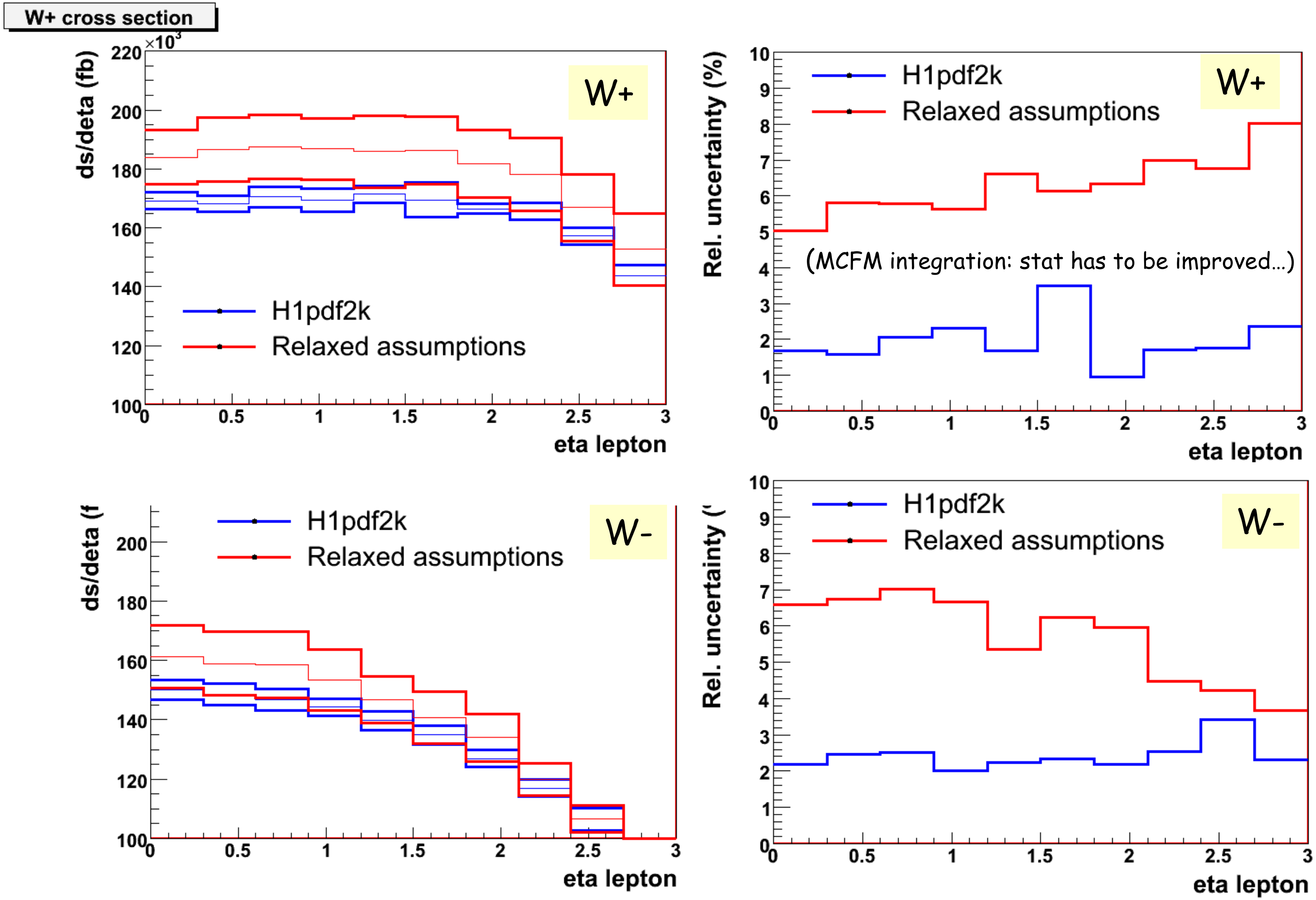
This fit

Chi2/ndf = 0.92
(923 for 1008)

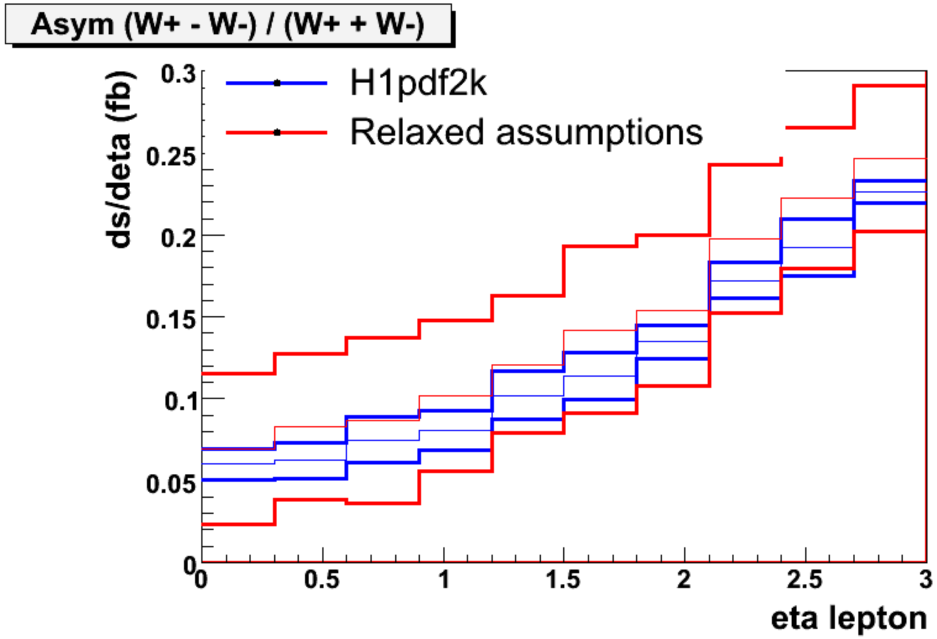
Global agreement with the fit of MK/BR.
Differences could be due to the treatment of BCDMS data, to be further investigated.

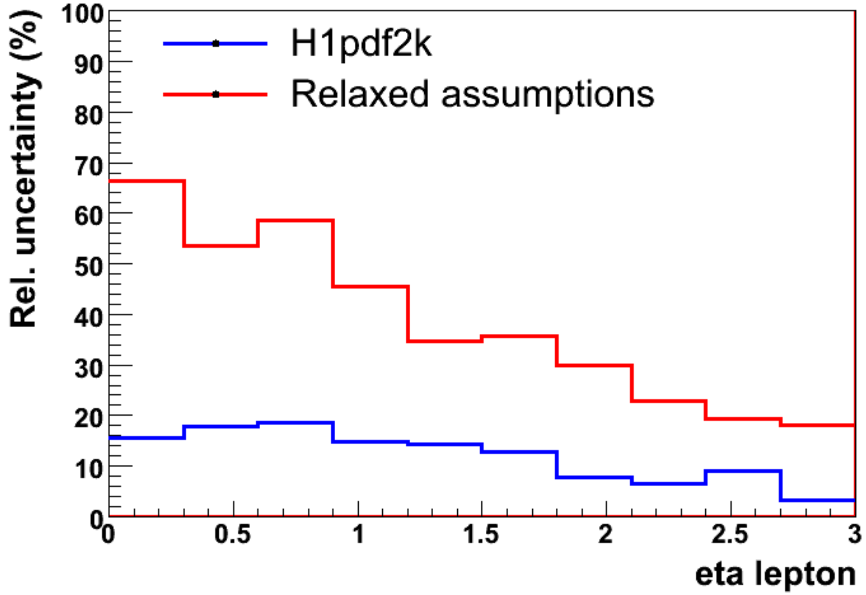
Slightly better chi2 of the H!+BCDMS fit when the low x assumptions are relaxed.

Uncertainties on W x-sections

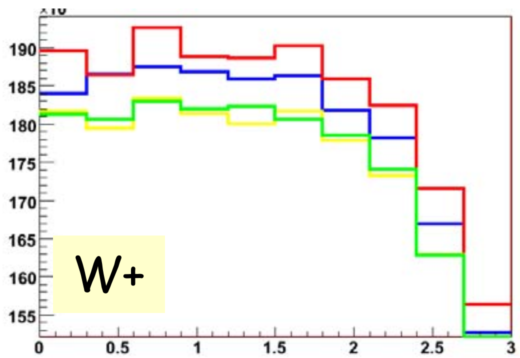


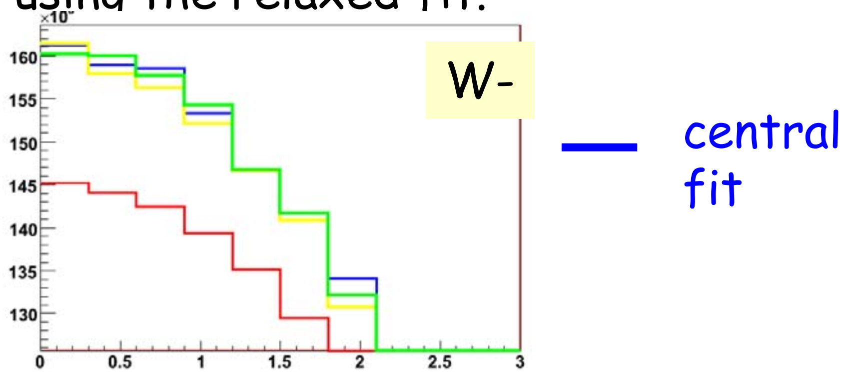
W Asymmetry





Uncertainty on the asymmetry using H1pdf2k sets is already large.
Larger than 50% in the central region, using the relaxed fit.





Conclusions

MK, 03/05

So far HERA has not resolved the light sea quarks at low x. Thus the QCD fits employ the ("reasonable") assumption that $\bar{u}=\bar{d}$ and that $u=\bar{u}$ and $d=\bar{d}$ at low x.

[This reasonable assumption was proven to be wrong at larger x ~ 0.1.]

Without these requirements the fits become unstable, existing lD data (BCDMS as used here) help but can't solve the problem as they are at higher x, as DY data.

- Took a first look at the effect of relaxing these assumptions on W @ LHC. At first sight the effect seems to be sizeable.
- Uncertainties on x-sections are typically 3x larger compared to what is obtained using H1pdf2k.
- Uncertainty on the W asymmetry seems to be large.
- i.e. W asymmetry might bring insights on the flavor symmetry of the sea at low x.